

# Cloudphase Study

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And many more!



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# Objectives of the study

- How can we bring the different datasets and measurement techniques together to get a broader, global(?) perspective of phase partitioning?
- Do different methodologies give similar results?
- Start with comparing different methodologies and platforms using observations overlapping in time and space (i.e. campaigns)
- Recycle existing data sets
- Efforts should result in a paper this summer

# What is this discussion about?

- Give opportunity to join
- Include more data sets?
- How to filter the data sets?
- How to make comparison as consistent as possible?
- What quantities for comparison?
  
- Please ask questions any time!

# How to define cloud phase?    How to measure cloud phase?

- Phase Frequency
- Ratio of Water Contents
- Ratio of Water Paths

- Satellite
- Ground based remote sensing
- In situ

# Definition & Methods

	Phase Frequency	Water Path Ratio	Water Content Ratio
In situ	(✓)	✗	✓
Ground based remote sensing	✓	✓	✓
Satellite	✓	(✓) ?	✗
Model (?)	✓	✓	✓



Only mixed phase?

Best definition depends on question?

# Compare with... ?

	Cloud top temperature	Turbulence	Aerosol properties (?)	Humidity	More?
In situ	(✓)	(✓)	✓	✓	
Ground based remote sensing	(✓)*	✓	(✓)	(✓)*	
Satellite	✓	✗	(✓)	✗	
Model (?)	✓	✓	✓	✓	

\* From model data

# Methods/data sets



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# CloudSat



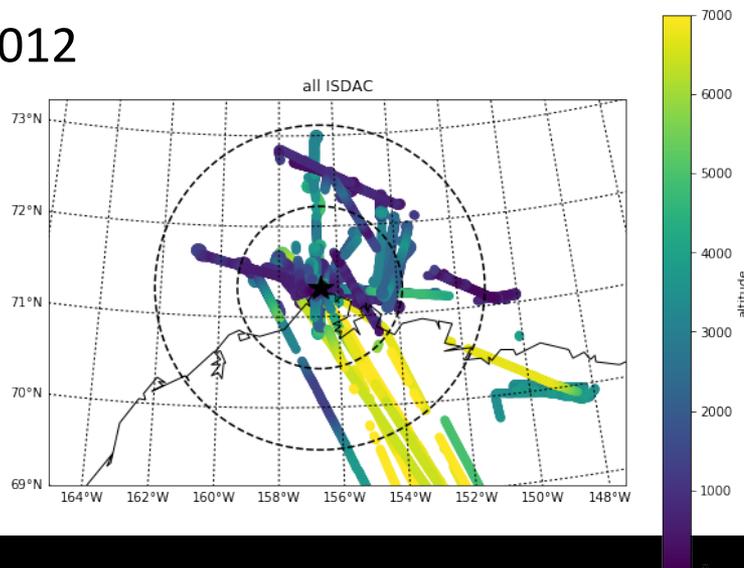
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# ISDAC in situ

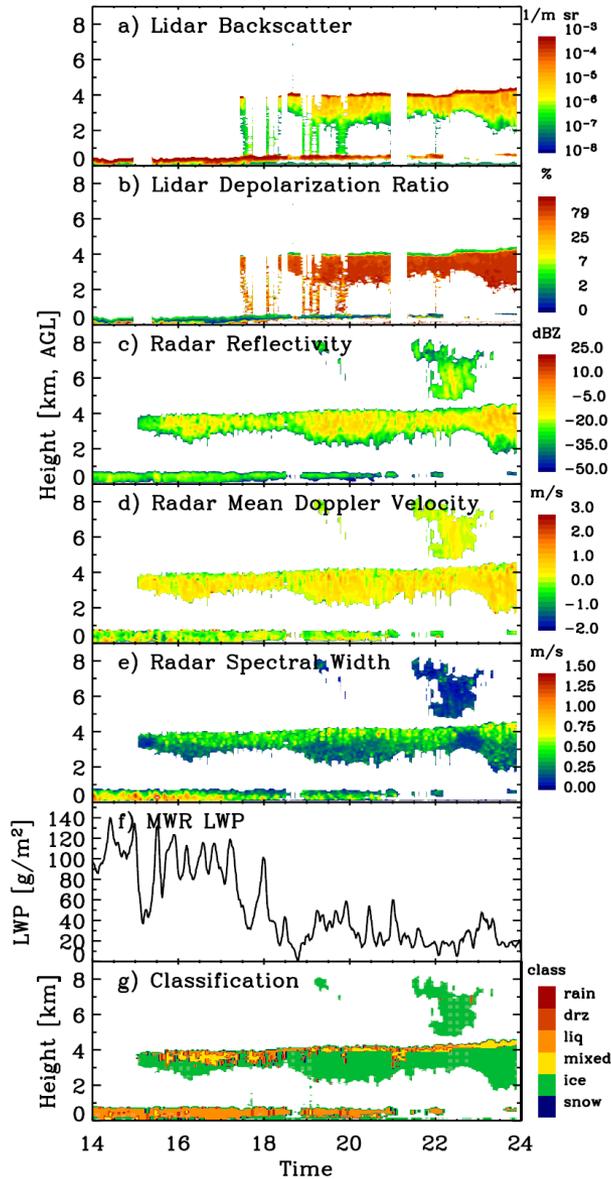
- Indirect and Semi-Direct Aerosol Campaign (ISDAC)
- Stratocumulus ice clouds
- April 2008 in Alaska
- Convair 580 with in situ instruments
- Phase classification Jackson et al 2012
- Closer than 200 km to Barrow
- Single layer clouds prevailed for certain flights
- No random sampling of clouds
- Unknown whether cloud precipitates or not



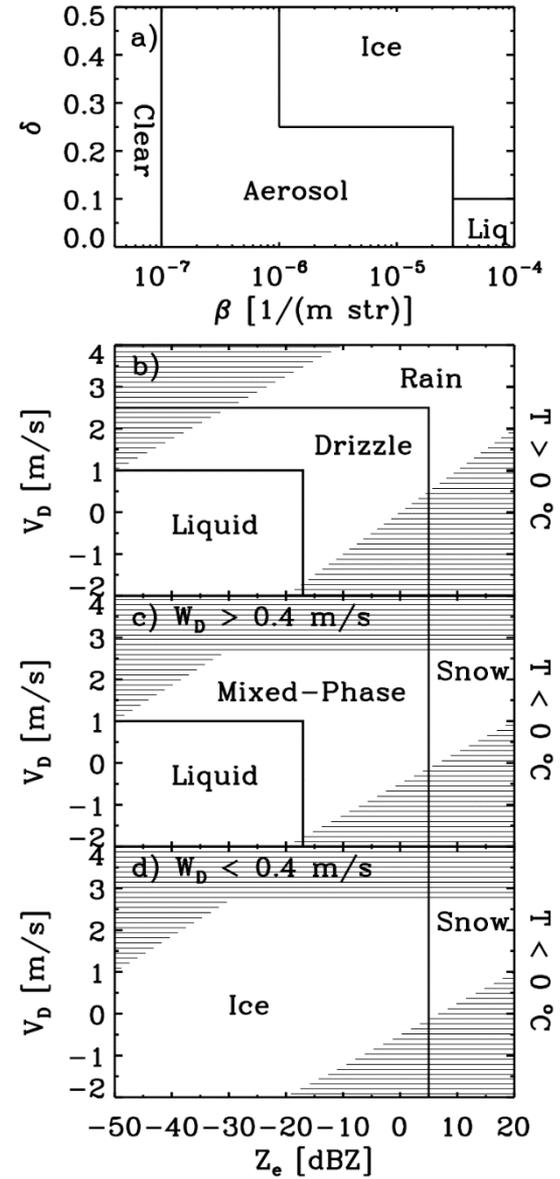
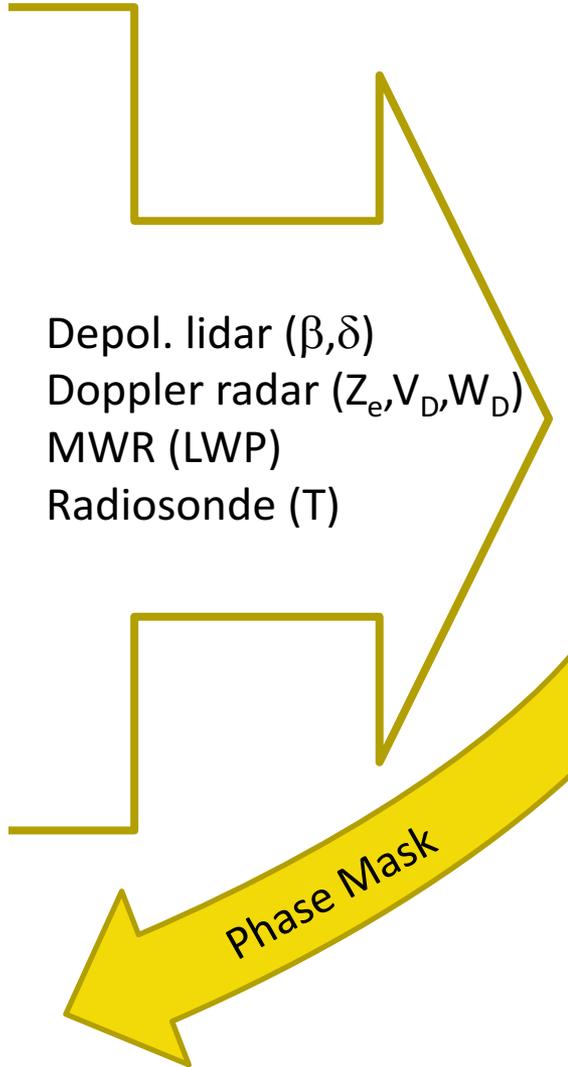
McFarquhar

# A ground-based multisensor cloud phase classifier

Shupe 2007



Depol. lidar ( $\beta, \delta$ )  
 Doppler radar ( $Z_e, V_D, W_D$ )  
 MWR (LWP)  
 Radiosonde (T)



# ISDAC ground based radar

- Based on Shup-Turner algorithm
- Rain/Snow/Drizzle discarded (in pixel space, not column!)
- April 2008
  
- Radar calibration?

# CLOUDNET data

- Radar + lidar + microwave radiometer + model → cloud classification
- IWC retrieved from radar (Hogan et al. 2006) → IWP
  - For JOYCE calculation of Z-IWC (35 GHz MIRA radar)  
 $\log_{10}(\text{iwc} [\text{g/m}^3]) = 0.000242Z[\text{dBZ}]T[\text{degC}] + 0.0699Z[\text{dBZ}] \pm 0.0186T[\text{degC}] \pm 1.63$
  - For Ny-Ålesund (94 GHz RPG cloud radar)  
 $\log_{10}(\text{iwc} [\text{g/m}^3]) = 0.00058Z[\text{dBZ}]T[\text{degC}] + 0.0923Z[\text{dBZ}] \pm 0.00706T[\text{degC}] \pm 0.992$
- LWP retrieved from microwave radiometer
- Cloud top temperature from model
  - JOYCE: COSMO-EU 1.3.2011-28.5.2014, ECMWF IFS (29.5.2014-8.3.2016), GDAS (9.3.2016-3.1.2017)
  - Ny-Ålesund: GDAS data (global data assimilation system)
    - temporal resolution ~3 hours, vertical resolution changing with height from ~200 m to ~2 km, 20 vertical levels

How does that compare to Matt's classification?

# CLOUDNET data

Only including cases with....

- single cloud layers with geom. depth  $< 1$  km
  - → mainly thin liquid/mixed phase clouds and patches of cirrus
- no liquid precipitation or drizzle is detected
- IWP only included when retrieval flagged as “reliable”

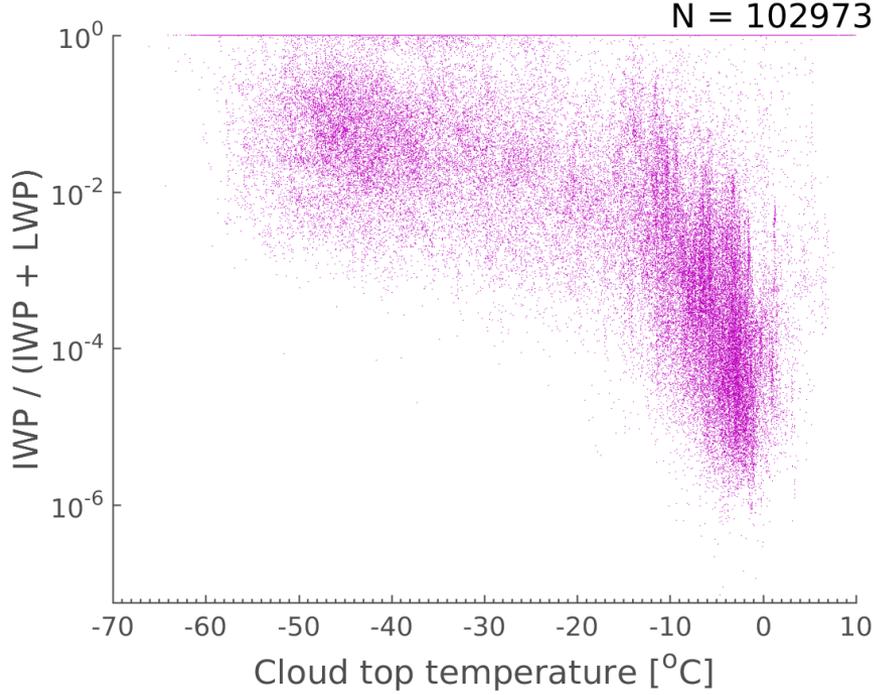
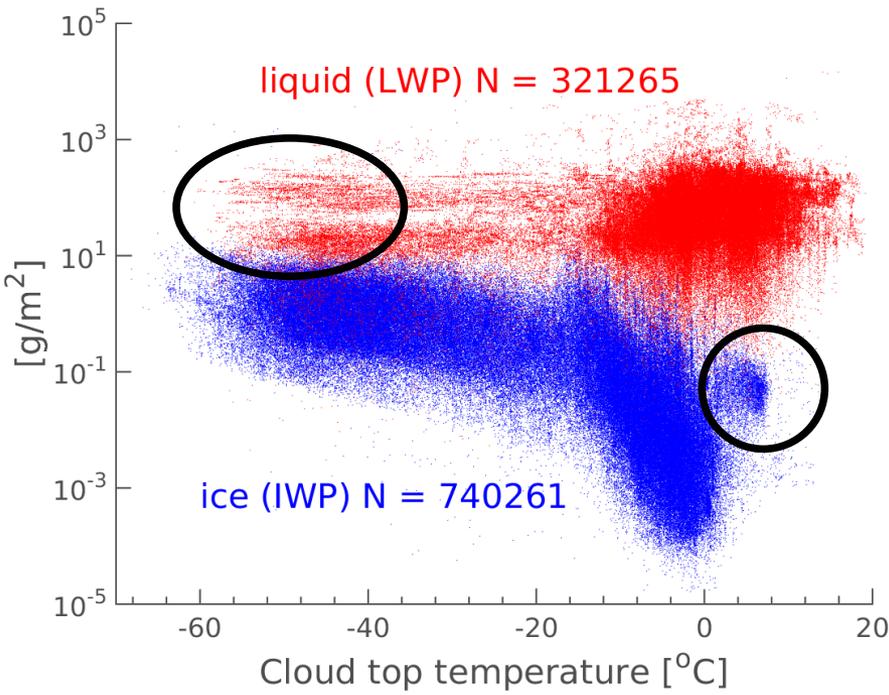
# CLOUDNET data

Only including cases with....

- single cloud layers with geom. depth  $< 1$  km
  - → mainly thin liquid/mixed phase clouds and patches of cirrus
- no liquid precipitation or drizzle is detected
- IWP only included when retrieval flagged as “reliable”
- For Ny-Ålesund: LWP is only analyzed when presence of cloud droplets is detected by active instruments (to exclude cases when MWR sees liquid earlier due to broader beam)

# JOYCE

01.03.2011 – 03.01.2017

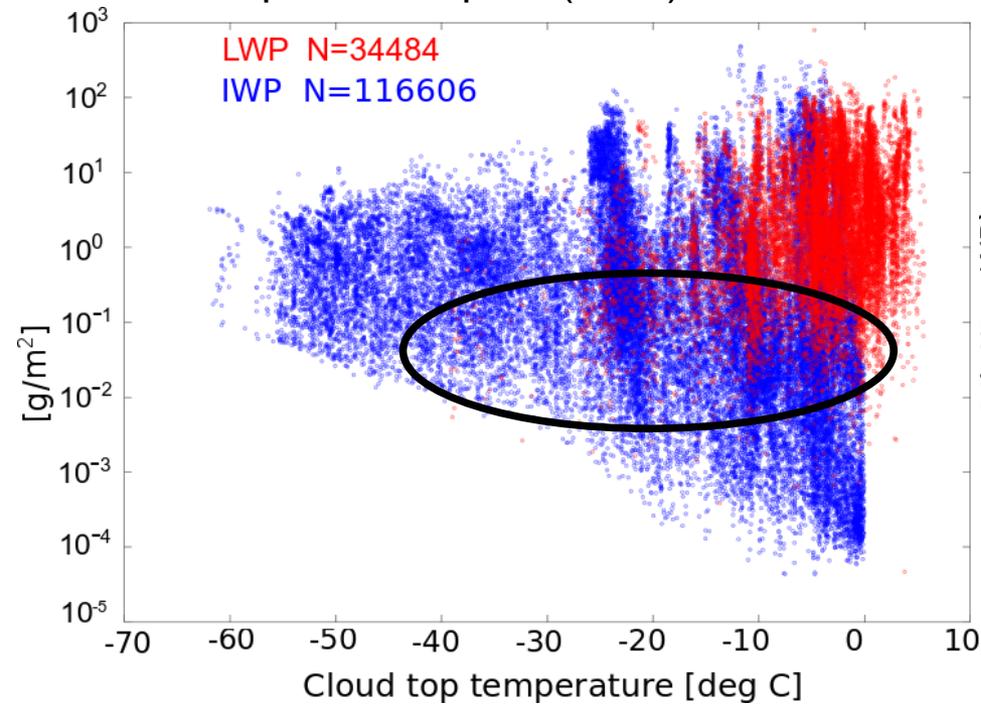


→ model issue?

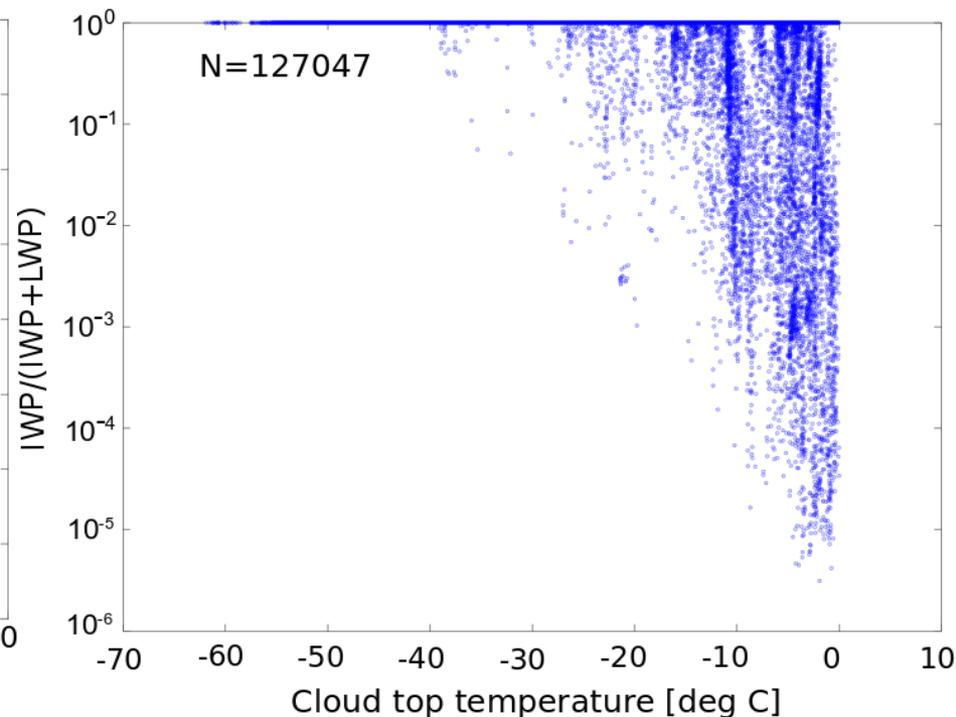
# Ny-Ålesund

10.06.2016 – 01.02.2017

Ice water path (IWP) and  
liquid water path (LWP)



Ratio of IWP and  
total water path (TWP=IWP+LWP)

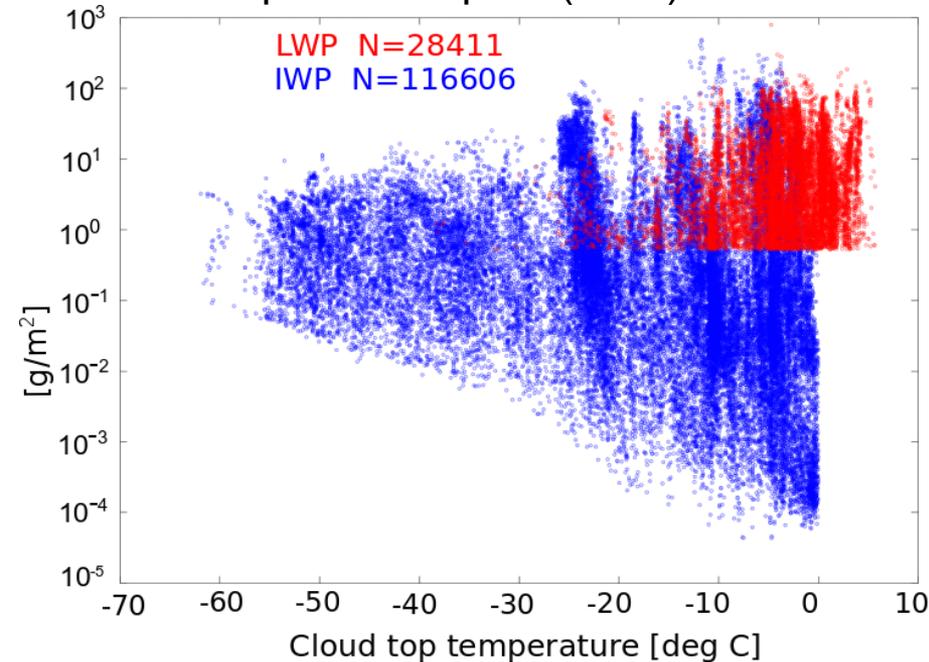


- small values of LWP below the detection limit of the MWR
- positive values of cloud top temperatures for IWP due to relatively low accuracy of GDAS

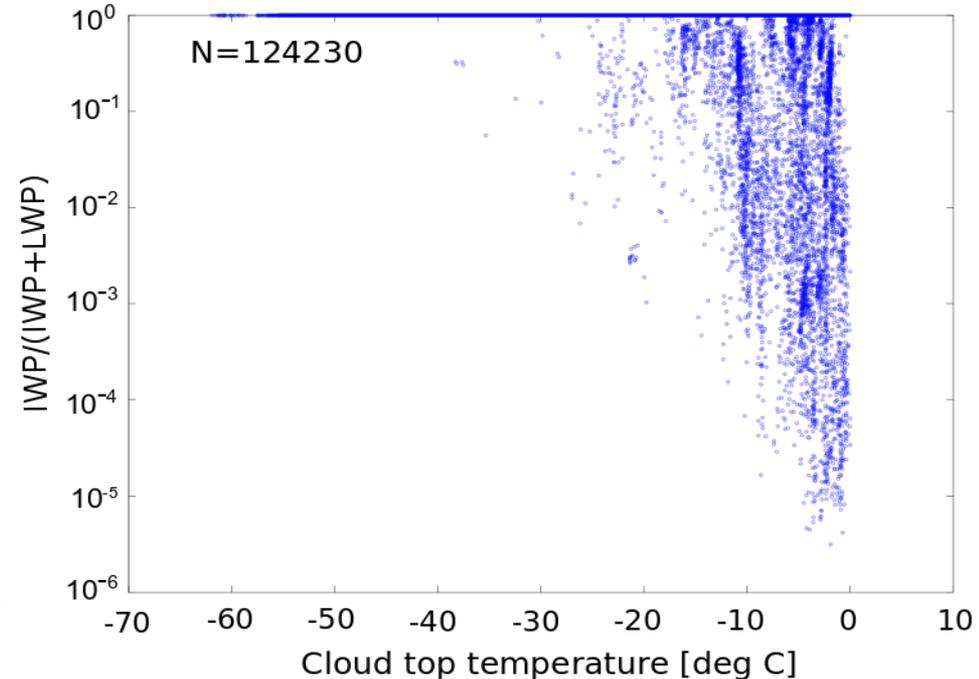
# Ny-Ålesund (filtered version)

10.06.2016 – 01.02.2017

Ice water path (IWP) and  
liquid water path (LWP)



Ratio of IWP and  
total water path (TWP=IWP+LWP)



- Filter small values of  $\text{LWP} < 0.53 \text{ g/m}^2$
- (calculated from clear sky days  $\text{mean(LWP)} + 3 \cdot \text{STdev(LWP)} = 0.53 \text{ g/m}^2$ )
- IWP data with positive cloud top temperatures are removed

# Results



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# Filter data set

Consistent filtering of the data sets is crucial!

	Precipitation	No. of cloud layers	Used Radius	Cloud Top Heights (?)	??
ISDAC in situ	Only non-precipitating part considered	separated	200 km		
ISDAC Ground based	Only non-precipitating part considered	separated	-		
Jülich CloudNet	Precipitating clouds REMOVED	Single layer (for now)	-		
CloudSat	Precipitation included into classification		2.5° x 2.5° (for now)		

# Compare frequency



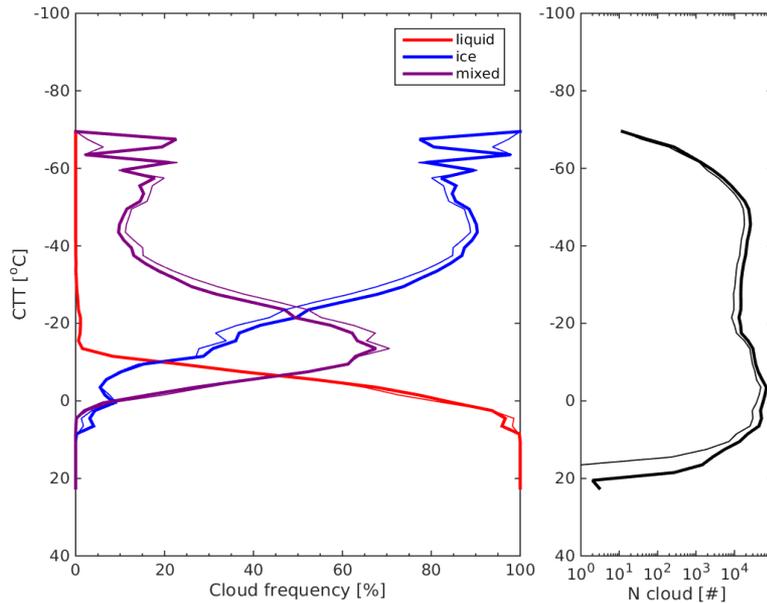
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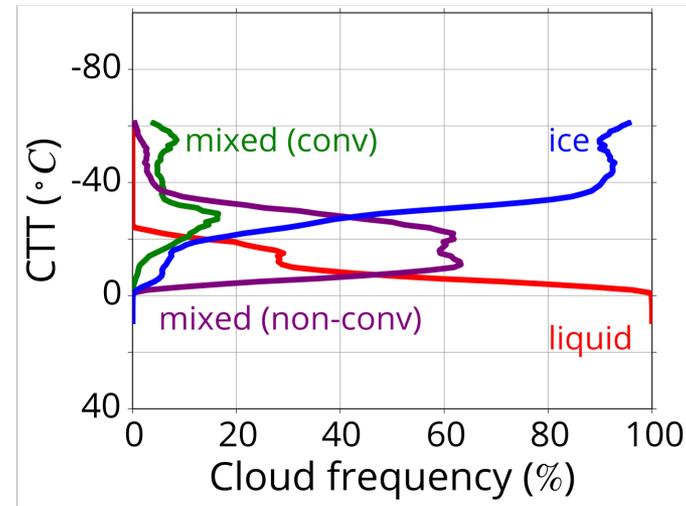
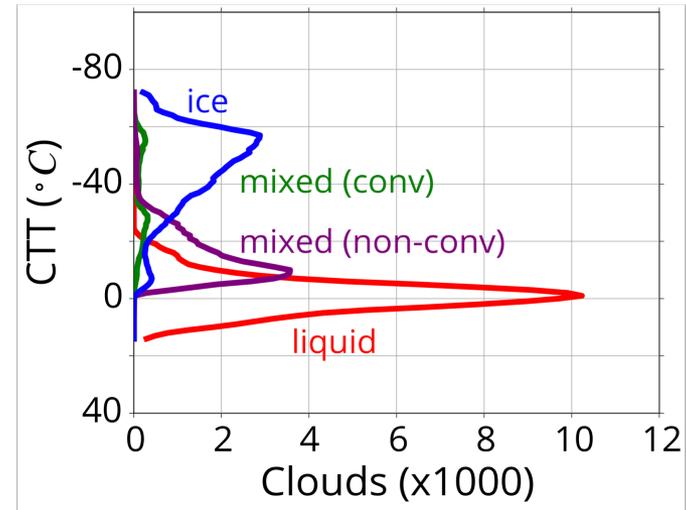
# JOYCE: ground vs space based

Thin line: Sept-April since 2011  
 Thick line: All data since 2011



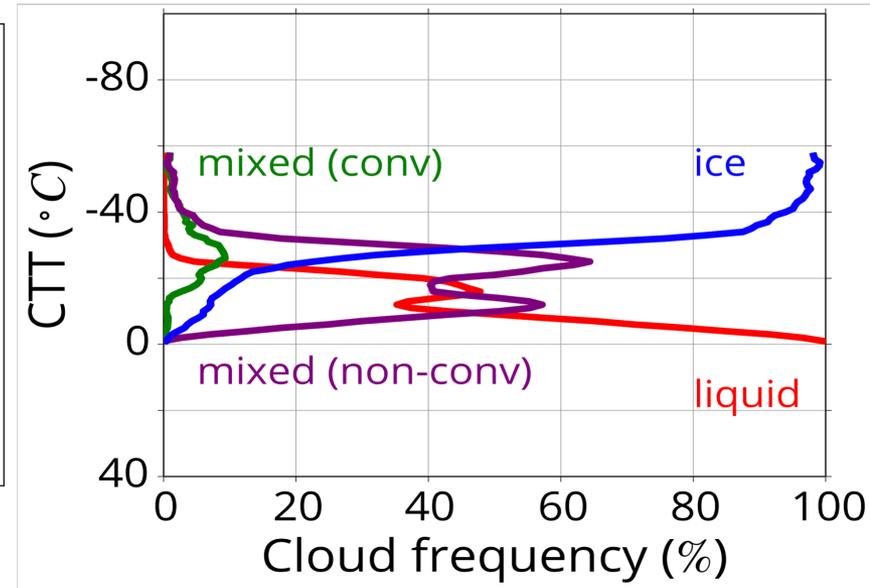
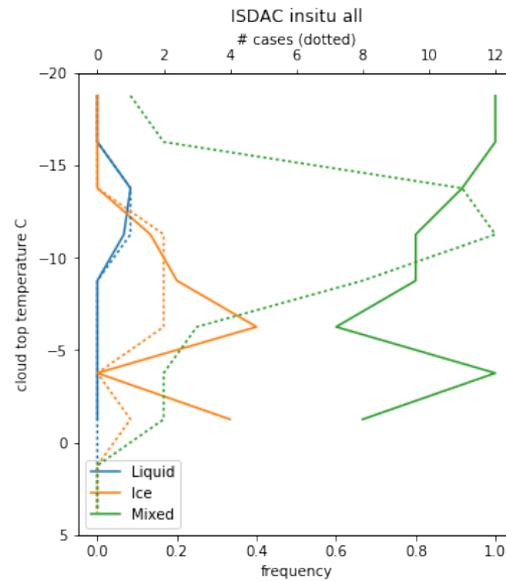
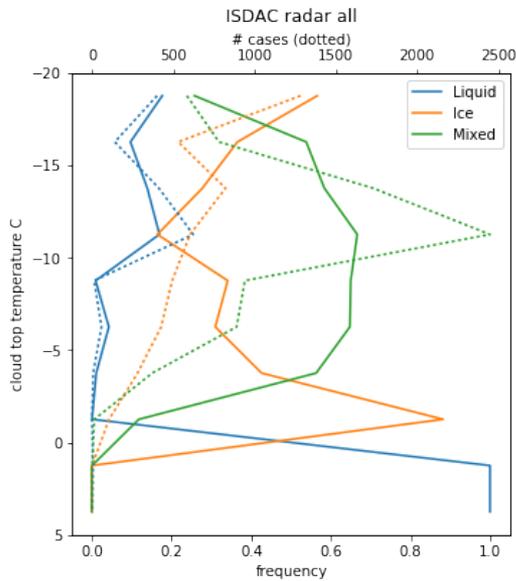
Provided by Rosa Gierens et al.

Sept-April 2010/11



Provided by Tristan L'Ecuyer et al.

# ISDAC radar vs in situ vs satellite



# Compare Contents

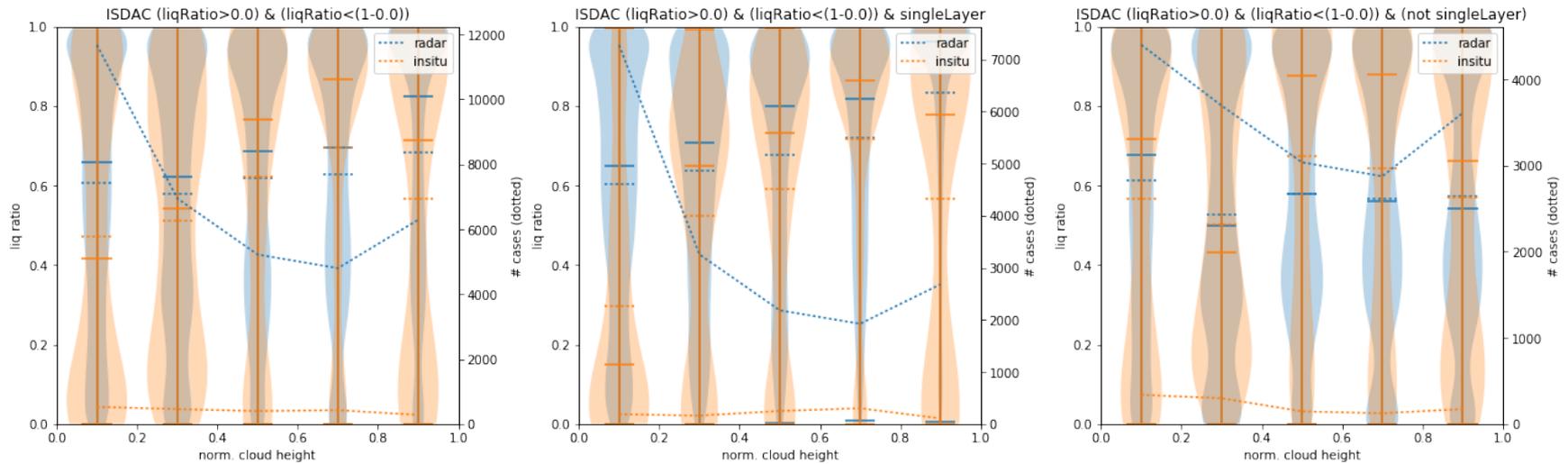


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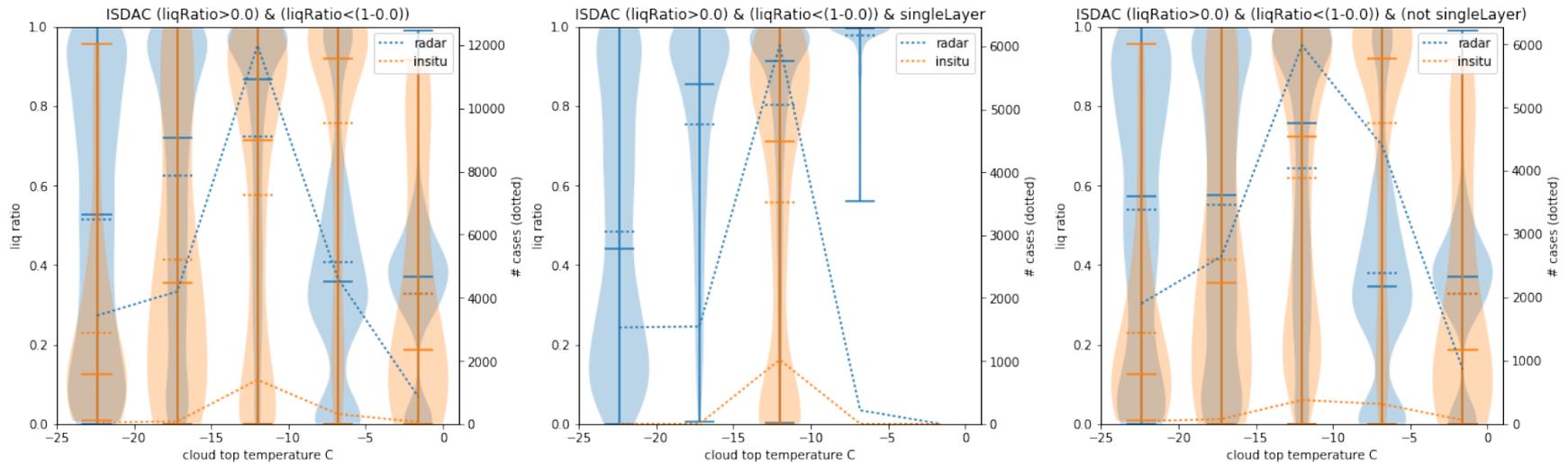


# ISDAC radar vs in situ: normalized cloud height



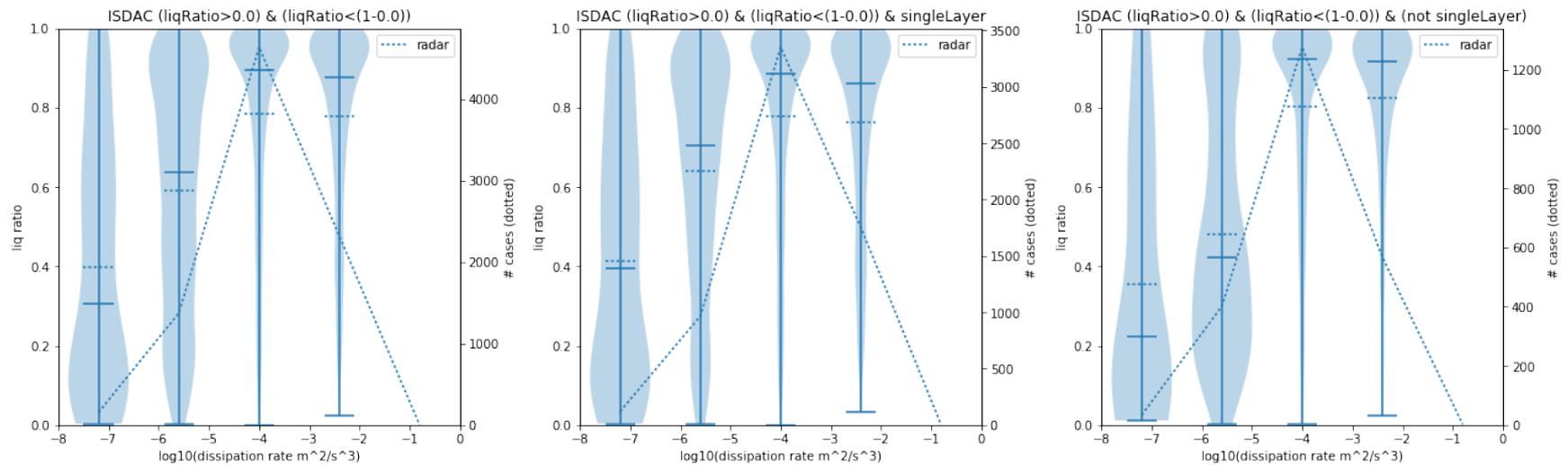
Only mixed phase clouds

# ISDAC radar vs in situ: cloud top temperature



In situ: probably positive temperature bias

# ISDAC radar vs in situ: turbulence/EDR



In situ: data mostly below sensitivity threshold of  $1e-3 \text{ m}^2/s^3$

# Comparing Paths

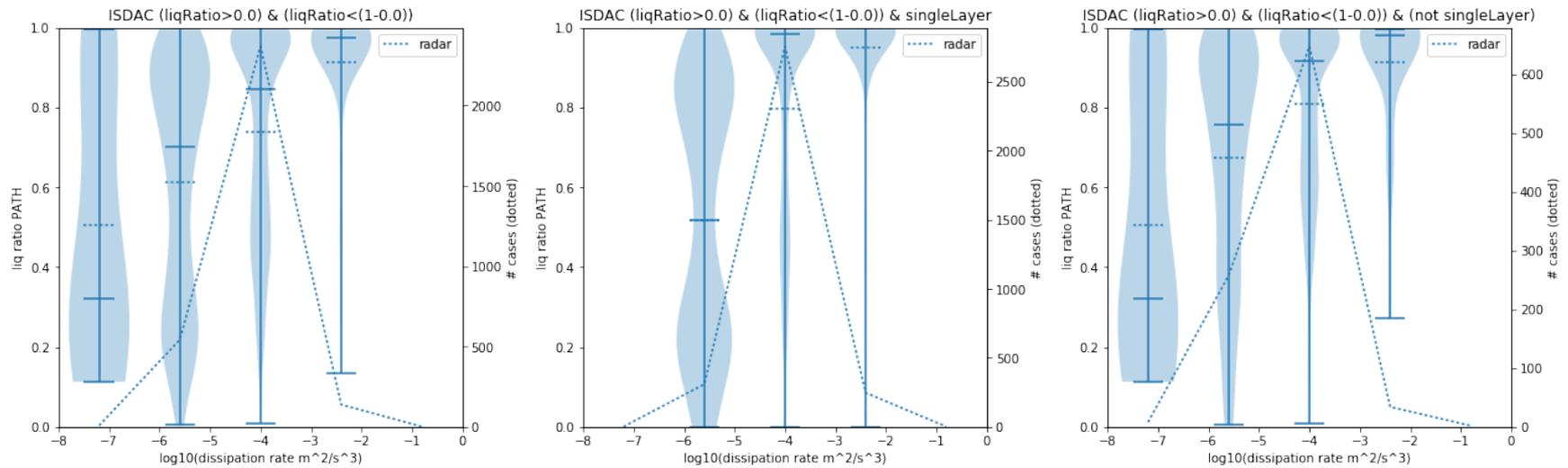


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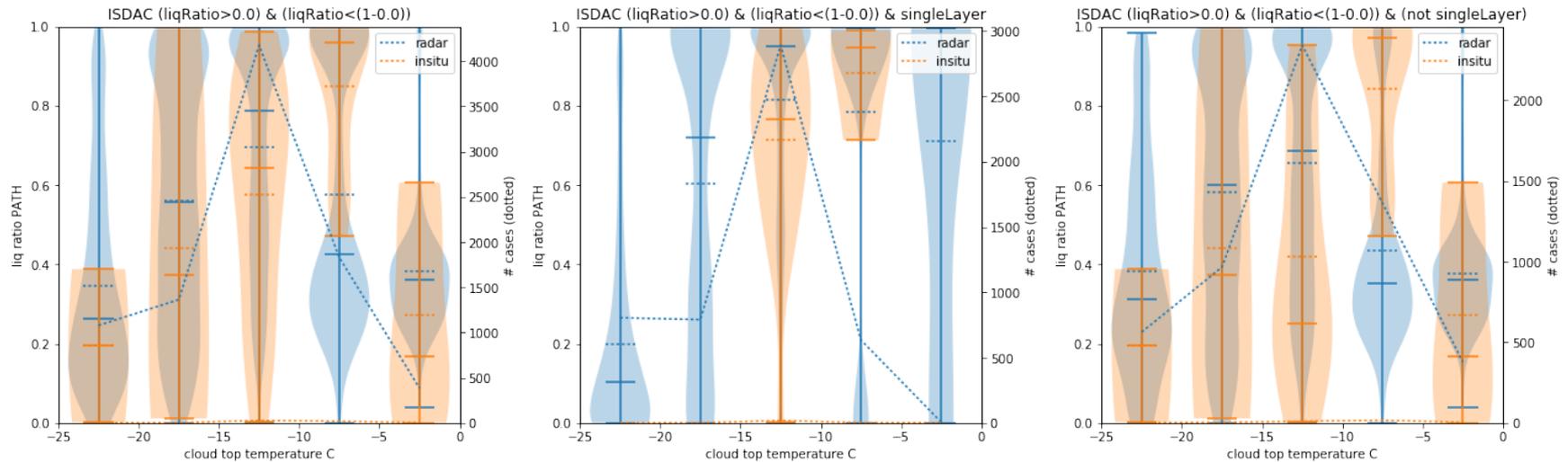
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# ISDAC radar vs in situ: turbulence/EDR



# ISDAC radar vs in situ: cloud top temperature



In situ: probably positive temperature bias

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ISDAC Ground based	Only non-precipitating part considered	separated	-	<100 m
Jülich CloudNet	clouds with precip or drizzle REMOVED	Single layer clouds	-	<100 m
CloudSat	Precipitation included into classification	-	-	2.5° x 2.5°

# Additional Data sets?

- Thin line between enhancing study and getting distracted
- Recycling of existing data sets
- For mid-latitudes: long data sets required to get sufficient CloudSat coverage, but Cloudnet implemented at many sites!
- ISDAC: expand ground based data beyond ISDAC?
- AWARE: Ground based data not processed yet
- SGP: Lots of convective events
- Ny-Ålesund Svalbard: rather short data set, no in situ data (yet)
- Include one GCM? Or Reanalysis?

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